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Is there any risk in a symbiotic species associating with an endangered one? A case of a phoronid worm growing on a *Ceriantheomorphe* tube

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Abstract: The conservation of emblematic threatened species is in highlight nowadays. Interestingly, few invertebrate groups attract scientific attention on this issue while they constitute the vast majority of animal biodiversity. Nevertheless, many invertebrate species are nowadays at risk of extinction. This means that plenty of species are currently disappearing out of sight. During a survey in the southwestern Atlantic Ocean tubes of an endangered species of cerianthid were sampled. This study reports for the very first time the occurrence of the species *Phoronis australis* in southwestern Atlantic waters and the association of phoronids with the genus *Ceriantheomorphe*. This raises questions on mutual extinction risks for symbiotic species and also on the criteria for their inclusion on Red Lists.

Résumé : *Existe-t-il un risque d'extinction pour une espèce symbiotique associée à une espèce en danger ? L'exemple d'un phoronidien se développant sur le tube d'une annélide cérianthe.* Quand il s'agit de conservation les espèces emblématiques menacées sont systématiquement mises sous les feux de la rampe. Cependant, peu de groupes d'invertébrés attirent l'attention alors qu'ils constituent la grande majorité de la biodiversité animale. Néanmoins, de nombreuses espèces d'invertébrés sont aujourd'hui en danger d'extinction. Cela signifie que de nombreuses espèces disparaissent actuellement sans que quiconque ne s'en aperçoive. Lors d'une étude dans le sud-ouest de l'océan Atlantique des spécimens d'une espèce menacée de Cerianthidé ont été échantillonnés. Cette étude rend pour la première fois compte de la présence de *Phoronis australis* dans les eaux sud-ouest de l'Atlantique ainsi que l'association de Phoronidiens avec le genre *Ceriantheomorphe*. Cela soulève la question des risques d'extinction mutuelle des espèces symbiotiques ainsi que des critères d'inscription de telles espèces sur les listes rouges.

Keywords: Association ● Phoronida ● Cnidaria ● Ceriantharia ● Extinction

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Introduction

A search of the literature for the term "endangered species", results in most being related to "mammals", "fishes", "turtles" and others vertebrates. This shows how invertebrates are neglected when discussing conservation policies, as they rarely appear on species red lists (Stampar & Silveira, 2006). The limited knowledge on extinction risks involving invertebrates often only becomes apparent after the event itself, as in the case of four species of gastropod mollusks (Carlton, 1993). Information on species extinction is usually related to environmental problems, mainly habitat loss (see more in Powles et al., 2000; Mace et al., 2008), suggesting that destruction of habitats is the primary reason for the extinction of the species. Without a suitable place to live, a species is unable to survive (New, 1995). Consequently, what would be the destination of a species living only in a symbiotic relationship with a threatened or endangered species? An example of this is a phoronid worm species occurring off the Brazilian coast.

The Phoronida are divided into two genera: *Phoronis* Wright, 1856 and *Phoronopsis* Gilchrist, 1907. The genus *Phoronis* is composed of seven species (Emig et al., 2001). Off the Brazilian coast, only three phoronid species have been recorded, *P. hippocrepia* Wright, 1856, *P. ovalis* Wright, 1856 and *P. psammophila* Cori, 1889 (Forneris, 1959 & 1969).

Up to now, phoronid diversity is small, with most of the species referenced as cosmopolitan. However, some recent molecular analyses are showing that this supposition is not correct (Santagata & Cohen, 2009).

Symbiosis between phoronids and cerianthids is well known (Emig et al., 1972), although the precise ecological relationships have not been investigated. The aim of this contribution is to report the first record of *Phoronis australis* Haswell, 1883 occurring in the southwestern Atlantic Ocean, and its symbiotic relationship with *Ceriantheomorphe brasiliensis* Carlgren, 1931, and comments on the ecological implications of this relationship.

Material and Methods

Ten phoronid individuals (ranging from 1 to 3 cm long) were found growing on the tube of a burrowing sea anemone of *Ceriantheomorphe brasiliensis* Carlgren, 1931 (ca. 25 cm in length). The cerianthid was collected close to the Laje de Santos State Marine Conservation Park (24°15'48"S-46°12'00"W). The site is within a small island complex located 23 nautical miles (42 km) southeast of Santos County (São Paulo State, Brazil) (Fig. 1). Material was collected on September 22nd, 2007 by Scuba diving with Enriched Air Nitrox at a depth of 36.5 m, under the scientific supervision of the NGO Instituto Laje Viva. The site is within the Laje de Santos State Marine Park and the sample was collected with IBAMA - SISBIO authorization number 10508. Identification of the phoronid (*Phoronis australis*) after histological methods, was based on the distribution of the longitudinal muscles (see Forneris, 1987). Identification of the cerianthid (*Ceriantheomorphe brasiliensis*) followed Carlgren (1931). The Scanning Electron Microscopy (SEM) preparations followed the methods of Danilatos (1988).

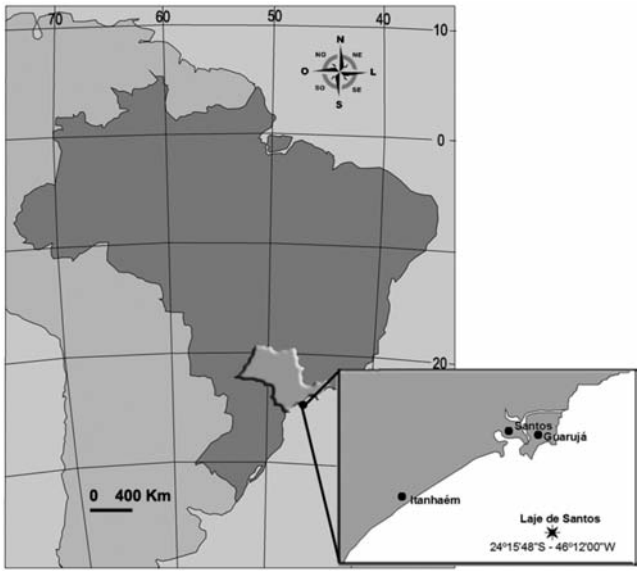


Figure 1. Brazil map showing the location of Laje de Santos, São Paulo state.

Figure 1. Carte du Brésil montrant l'emplacement de Laje de Santos, état de São Paulo.

Results

Superphylum LOPHOTROCHOZOA
Phylum PHORONIDA Hatschek, 1888
Genus *Phoronis* Wright, 1856
Phoronis australis Haswell, 1883
(Figs 2-5)

Examined material

Ten specimens: one deposited in the marine invertebrate collection of the Museu de Zoologia da Universidade de São Paulo under MZUSP 18453, three used for histological preparations, one specimen used for SEM.

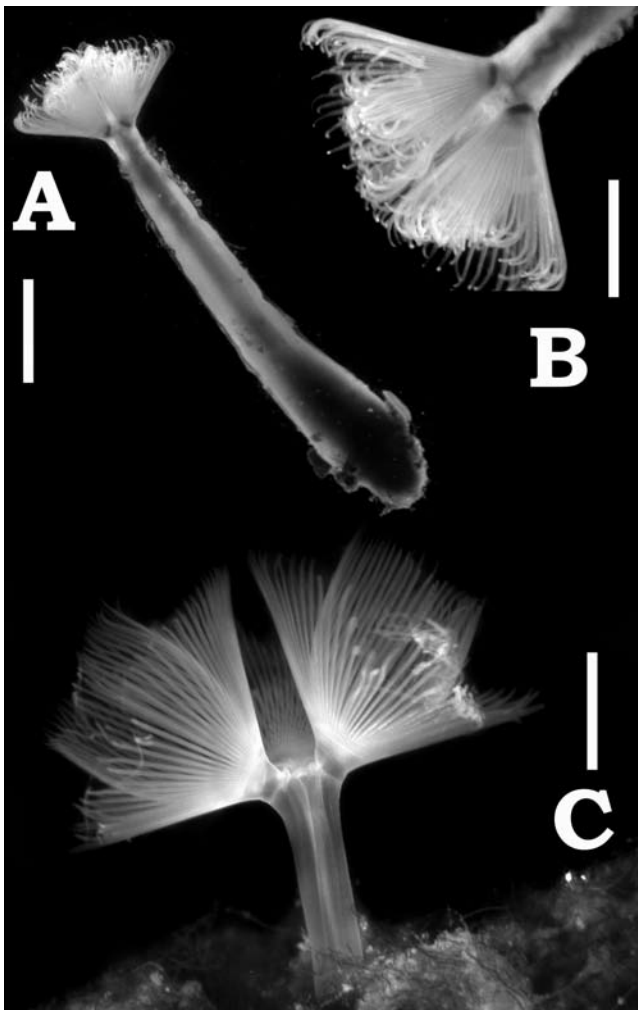


Figure 2. *Phoronis australis* Haswell, 1883. **A.** Whole living animal. Scale: 0.5 cm. **B.** Detail of the lophophore. Scale: 0.3 cm. **C.** A living animal on the cerianthid tube. Scale: 0.6 cm.

Figure 2. *Phoronis australis* Haswell, 1883. **A.** Animal vivant. Echelle : 0,5 cm. **B.** Détail du Lophophore. Echelle : 0,3 cm. **C.** Un individu vivant sur un tube de cérianthe. Echelle : 0,6 cm.

Description

Length when extended reaching 15-50 mm (Fig. 2A), body diameter 2-7 mm. Color white; anterior body pink or white. Lophophore spiral (Figs 2B-C & 3A) with 2.5 to 3.5 coils on either side, up to 1,000 ciliated tentacles (Fig. 3B), 5-8 mm in length. Stomach larger than intestine (Fig. 4, ST x INT), visible nerve cord on left mesentery basis (Fig. 4, NC). Arrangements of longitudinal muscles (mean value): Oral Coelom Left (18), Oral Coelom Right (17), Anal Coelom Right (6), Anal Coelom Left (6) (within the range given by Emig & Marche-Marchad (1969) for *Phoronis australis*). The general formula for longitudinal muscle bundles are presented below:

Phoronis australis general formula

$$\frac{14\text{-}65 \mid 13\text{-}27}{4\text{-}17 \mid 5\text{-}19}$$

Formula of Brazilian specimens of *Phoronis australis*

$$\frac{18 \mid 17}{6 \mid 6}$$

Distribution

Phoronis australis is until now considered a cosmopolitan species (for world distribution see http://paleopolis.rediris.es/Phoronida/SYST/AUST/aust_ADULT.html) (Fig. 5). Herein, *P. australis* is recorded for the first time from the south-western Atlantic, at Laje de Santos, Brazil (Fig. 1). Currently *Ceriantheomorphe brasiliensis* is known from only two published records (Fig. 5). The cerianthid was previously described from the south-western Atlantic (see Fig. 1) Ilha Bela (Brazil) (I: Carlgren, 1931), and has been recorded in the Gulf of Mexico (II: Carlgren & Hedgpeth, 1952; Hedgpeth, 1954).

Discussion

Remarks on Biology

Phoronis australis has been consistently found associated with the tubes of cerianthids of the genera *Cerianthus* (Emig, 1973) and *Pachycerianthus* (Den Hartog, 1977; Carter, 1995). This suggests that it is a case of obligatory commensalism, with the phoronids using the cerianthid tubes as substrata (for more details see Emig et al., 1972). *Phoronis australis* is found from the intertidal zone down to 40 m depth. Our specimens were recorded 36.5 m deep. Of the ten known species of Phoronida (genera *Phoronis* and *Phoronopsis*), *P. australis* is the only one known to burrow into the tubes of cerianthids, where they penetrate down to the inner layer and built its own tube to exterior. The tube of a single cerianthid can house up to 100 phoronids (Emig, 1979). *P. australis* symbiosis has been defined as inquilinism (Emig et al., 1972). It is based on three mutual relationships, viz., the substratum (the host's tube itself), food (both are suspension feeders) and protection (a muscular contraction of the cerianthid is a warning to phoronid contract) (see more in Emig et al., 1972) Inquilinism is the kind of relationship between two organisms, whereby one benefits and the other is neither significantly harmed or benefits (Pianka, 1999). A description of this type of symbiotic relationship is given by Moran (2006). The distinction between this type of relationship to a parasitic one is very tenuous (for more details see Leung & Poulin, 2008). The relationship between phoronid and cerianthids should be reviewed, taking into account the effects of phoronid settling in the

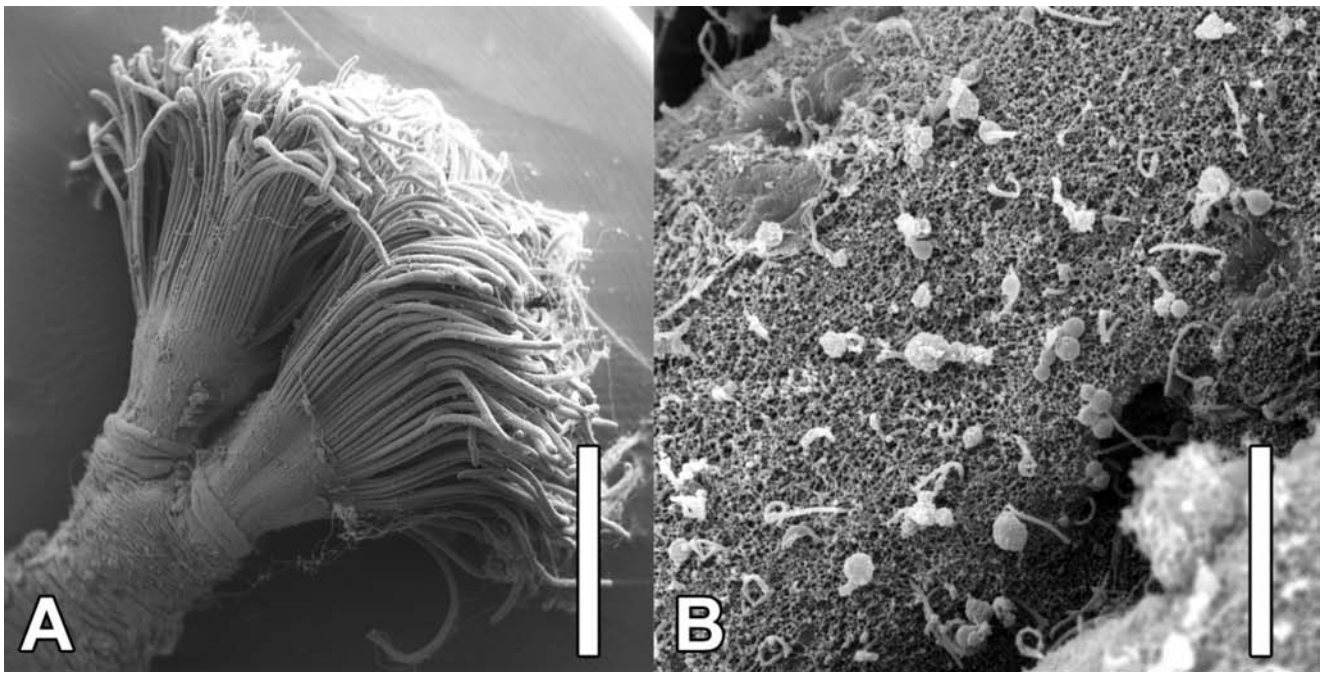
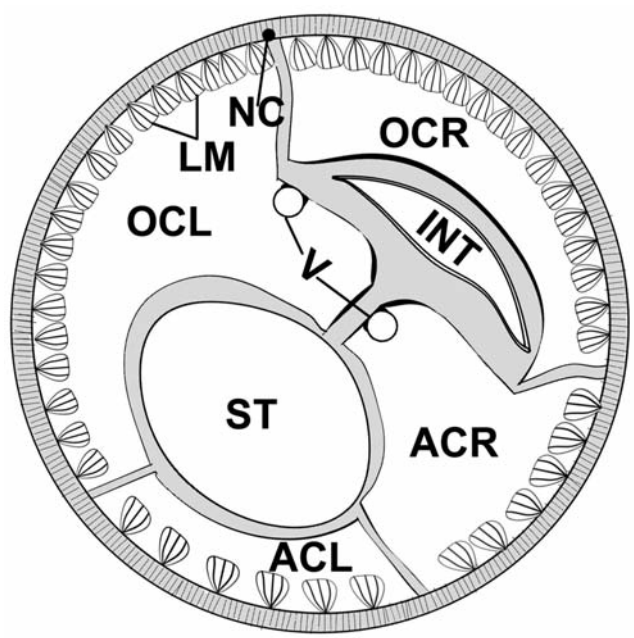


Figure 3. *Phoronis australis* Haswell, 1883. Scanning electron microscopy. **A.** Lophophore. Scale : 600 µm. **B.** Detail of tentacle surface. Scale: 10 µm.

Figure 3. *Phoronis australis* Haswell, 1883. Microscopie électronique à balayage. **A.** Lophophore. Echelle : 600 µm. **B.** Détail de la surface des tentacules. Echelle : 10 µm.



early stages of their sessile life-cycle on cerianthids tubes. For example dense populations of phoronids lodging in a cerianthid tube may hinder the polyp host during feeding, whereas, on the other hand they may alert the small cerianthid as to possible predators (SNS per. obs.).

Figure 4. *Phoronis australis* Haswell, 1883. Schematic representation of a transversal section of an individual found in Brazilian waters. ACL: Anal Coelom Left. ACR : Anal Coelom Right. INT : Intestine. LM: Longitudinal muscles. NC: Nerve Cord. OCL: Oral Coelom Left. OCR: Oral Coelom Right. ST: Stomach. V: Vessels.

Figure 4. *Phoronis australis* Haswell, 1883. Représentation schématique d'une section transversale d'un individu récolté dans les eaux brésiliennes. ACL : Coelome anal gauche. ACR : Coelome anal droit. INT : Intestin. LM : Muscles longitudinaux. NC : Corde nerveuse. OCL : Coelome oral gauche. OCR : Coelome oral droit. ST : Estomac. V- Vaisseaux.

Ecological Implications

The impact of trawling on benthic community structures of the continental shelf results in mass destruction of these invertebrate communities (Hutchings & Ponder, 2003). This is shown by the numerous Brazilian museum specimens of *Ceriantheomorphe brasiliensis*, where the animals have been collected but damaged by trawling. This cerianthid is considered an endangered marine species and is included on the Brazilian Red List (MMA, 2004). Furthermore, there is the problem of commercial exploitation, as it can be used as an attractive aquarium

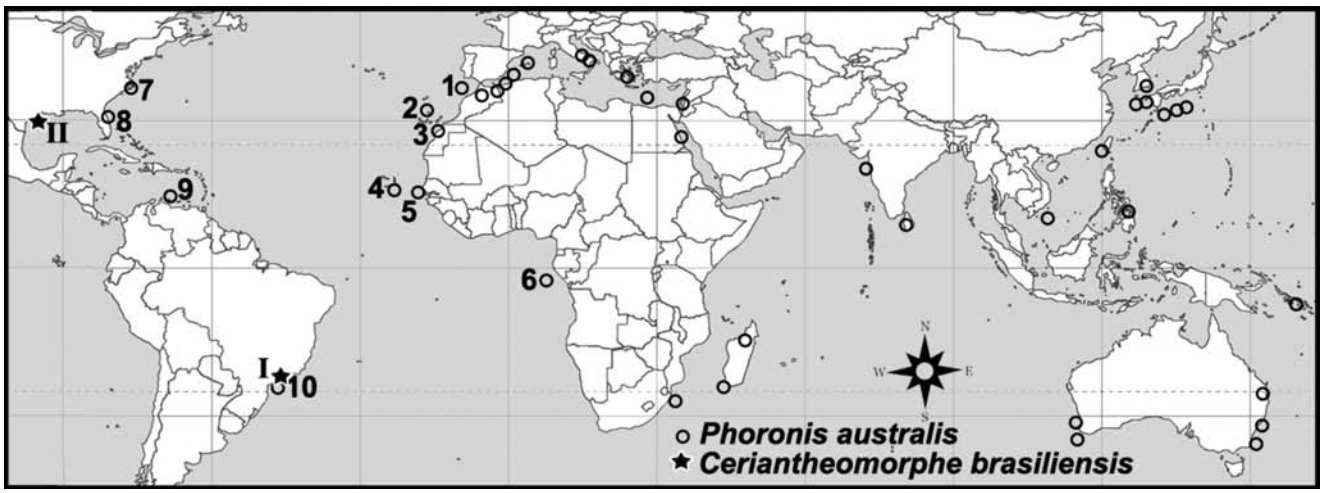


Figure 5. World map with records of *Phoronis australis* (circles) and *Ceriantheomorphe brasiliensis* (stars), with references to the Atlantic Ocean. *P. australis* has been registered in the southern Hemisphere in the Indian and Pacific Oceans (off the coasts of Madagascar, Mozambique, South Korea, New Caledonia and Australia). In the eastern Atlantic it has been recorded along the coasts of the Iberic Peninsula (1: Emig et al., 2005), Madera island (2: Wirtz, 2001), the Canary Archipelago (3: Ocaña et al., 1991; Emig et al., 2005), Senegal (4: Emig & Marche-Marchad, 1969), Cape Verde Islands (5: Wirtz, 2001) and São Tomé Island (6: Wirtz, 2003). In the northwestern Atlantic it has been noted at two points, viz., Sapelo Island, Georgia (USA) (7: Emig, 1975) and Hutchinson Island, Florida (USA) (8: Emig, 1982), and also in the Caribbean Sea, Curacao (Netherlands Antilles) (9: den Hartog, 1977). The first record for the south Atlantic and Brazil is Laje de Santos (10).

Figure 5. Carte du monde avec des records de *Phoronis australis* (cercles) et *Ceriantheomorphe brasiliensis* (étoiles), avec des références à l'Océan Atlantique. *P. australis* a été signalé dans l'hémisphère sud dans les Océans Indien et Pacifique (au large des côtes de Madagascar, le Mozambique, la Corée du Sud, Nouvelle-Calédonie et Australie). Dans l'Atlantique Est, il a été signalé le long des côtes de la péninsule ibérique (1 : Emig et al., 2005), Madera Island (2 : Wirtz, 2001), l'archipel des Canaries (3 : Ocaña et al., 1991; Emig et al., 2005), Sénégal (4 : Emig & Marche-Marchad, 1969), Cap-Vert (5 : Wirtz, 2001) et de São Tomé Island (6 : Wirtz, 2003). Dans l'Atlantique nord-ouest, il a été signalé à deux endroits, Sapelo Island, en Géorgie (USA) (7 : Emig, 1975) et Hutchinson Island, Floride (USA) (8 : Emig, 1982), ainsi que dans la mer des Caraïbes, à Curaçao (Antilles néerlandaises) (9 : Den Hartog, 1977). Le premier signalement pour l'Atlantique Sud et le Brésil est Laje de Santos (10).

ornament, thus explaining its disappearance from many areas (Pires & Castro, 2008). Currently, populations of this species are only occurring in protected areas (e.g. Laje de Santos).

Consequently, questions arise. Is *Phoronis australis*, through being associated with *C. brasiliensis*, also to be considered threatened? When using criteria of the International Union for Conservation of Nature (Amaral & Jablonski, 2005; IUCN, 2006; Mace et al., 2008), it is obvious that its inclusion on the Brazilian Invertebrate Red List should be proposed. Furthermore, when considering IUCN recommendations, Location (Criteria B and D) and Area of occupancy (Criteria A, B & D) (IUCN, 2006), its inclusion is obviously essential, for in a short while its habitat (cerianthid tubes) may no longer be found in the south-western Atlantic. This cerianthid species is only found in protected areas in Brazilian coast; however these areas are not fully safe. Conversely, without assessing species population viability, it is difficult to propose its inclusion on a Red List. Another question: is it possible that certain populations may be able to choose a substitute substratum? We have no answer, because this point needs to be investigated. These questions cannot be promptly answered, but they are imperative for arriving at a decision whether to include or not the species on a list of endangered species. Finally, is it enough to assess the viability of *Phoronis australis* populations off the Brazilian coast without cerianthids? We do not believe so, due to a lack of knowledge on the biology of this species.

The issues addressed highlight the lack of studies on symbiosis among invertebrate marine species. Thus, it is clear that comprehensive zoological studies are still required in many cases. The criteria applied in the protection of endangered invertebrate species are rudimentary, and are expressed in the restricted use of protected areas (e.g. parks, reserves). Conservation programs rarely focus on marine invertebrates. These programs are only applied to groups where there is some emotional interest mostly vertebrates (e.g. turtles, marine mammals). The widespread use of this type of program for top predators has increased the number of listings, thereby possibly leading to higher pressure on lower levels in the

food webs (see more in Estes, 1995). Thus, it is now a priority to draw up conservation programs focused on lower levels of the food webs (secondary producers), to so avoid restoring the populations of various species in detriment of others, notably those of invertebrate groups by the invertebrates are the most important component of fauna (European Community, 1986).

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